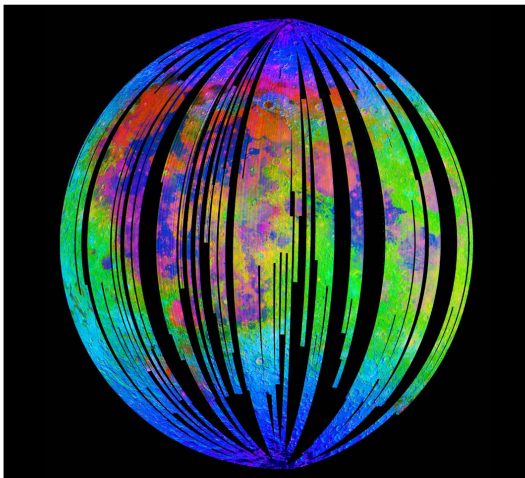




# Moon Mineralogy Mapper

## Unlocking the Mysteries of Earth's Moon

The Moon Mineralogy Mapper ( $M^3$ ) is a state-of-the-art, high-spectral-resolution imaging spectrometer that gives scientists their first opportunity to examine, characterize, and map the mineral composition of the Moon. It mapped 95% of the lunar surface from an altitude of 100 kilometers (62 miles) with selected targets that include such features as outcrops exposed at the walls and



*During each orbit,  $M^3$  took 260 simultaneous pictures, with all 600 pixels photographing the lunar surface, showing mountains, craters, and plains. Because each mineral has its own unique spectrum, images can be color-coded, creating a mineral map. In this mosaic, blue indicates water molecules detected at the surface.*

central peaks of large craters, complex volcanic terrain, boundaries where different kinds of rocks converge, unusual or rare compositions, and polar

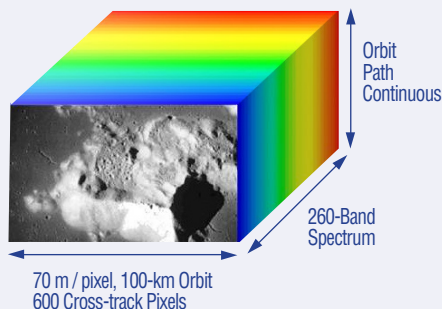
regions. The  $M^3$  instrument is one of 11 instruments that flew on board Chandrayaan-1, the Indian Space Research Organization's (ISRO) lunar orbiter mission (India's first deep space mission) which launched on October 22, 2008.

The Moon is a cornerstone to understanding early solar system processes. A detailed characterization of lunar surface mineralogy can dramatically improve our understanding of the Moon's origin and geological evolution, as well as the early development of the terrestrial planets (the rocky planets Mercury, Venus, Earth, and Mars).  $M^3$  may also help us locate resources on the Moon that may be useful for a lunar base.

### What is an "imaging spectrometer?"

An imaging spectrometer is a camera that distinguishes hundreds of different colors (wavelengths of light) including wavelengths that the human eye cannot see, rather than just the three colors (red, green, and blue) seen by a basic camera. Different minerals reflect or absorb different amounts of light depending on the wavelength. These "spectral signatures" seen by  $M^3$  allow us to identify the different minerals and map the locations of these minerals over the entire surface of the Moon. The  $M^3$  instrument provides the finest detail over the broadest spectral range among all the instruments that have ever flown to the Moon!

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### Image Information Cube

The images produced by the  $M^3$  imaging spectrometer can be thought of as a cube of information. The width is 600 pixels, each with a spatial resolution of 70 meters (230 feet) at the instrument's altitude; the length is an infinite strip along the instrument's orbital path (or wherever one chooses to crop the picture for an individual study), and the depth is 260 spectral channels.

## M<sup>3</sup> Fast Facts

Launch date (from India)	October 22, 2008
Launch Vehicle	Polar Satellite Launch Vehicle, India
Spacecraft	Chandrayaan-1, provided by India
Launch Site	Satish Dhawan Space Center, India
Cruise Time	5.5 days
Mission Duration	2 years
Final Orbit	100 kilometers (62 miles), polar
Field of View	40 kilometers (24 miles)
Imaging Modes	Global — 140 meters (460 feet) per pixel resolution Target — 70 meters (230 feet) per pixel resolution
Ground Station	Bangalore, India
Science Data	ISRO to JPL to Science Team

## M<sup>3</sup> Instrument Overview

Single focal plane array detector with spectral range of 430 to 3000 nanometers, which is where diagnostic features occur for all common rock-forming minerals and hydrous phases (detect trace amounts of H<sub>2</sub>O and OH).

600 spatial elements

260 spectral channels

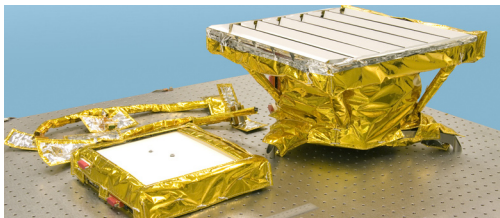
High signal-to-noise ratio

Pushbroom grating spectrometer consisting of three major elements:

- optical bench subassembly
- electronics subassembly
- thermal subassembly

Low in weight — Mass: 8.34 kilograms (18.3 pounds)

Low in power consumption — Power: 13 watts



*The M<sup>3</sup> instrument in flight configuration — at left is the instrument electronics subassembly; at right, the optical bench subassembly.*

For more information about M<sup>3</sup> and the Chandrayaan-1 mission, go to:

<http://m3.jpl.nasa.gov>

<http://sse.jpl.nasa.gov/missions/profile.cfm?Sort=Alpha&Letter=M&Alias=Moon%20Mineralogy%20Mapper%20instrument>

<http://discovery.nasa.gov/M3.html>

<http://www.isro.org/chandrayaan>

<http://m3science.geo.brown.edu>

<http://m3.cofc.edu>

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[www.nasa.gov](http://www.nasa.gov)



# Earth's Moon

The regular daily and monthly rhythms of Earth's only natural satellite, the Moon, have guided time-keepers for thousands of years. Its influence on Earth's cycles, notably tides, has also been charted by many cultures in many ages. More than 70 spacecraft have been sent to the Moon; 12 astronauts have walked upon its surface and brought back 382 kilograms (842 pounds) of lunar rock and soil to Earth.

The presence of the Moon stabilized Earth's wobble. This has led to a much more stable climate over bil-

lions of years, which may have affected the course of the development and growth of life on earth.

How did the Moon come to be? The leading theory is that a Mars-sized body once hit Earth and the resulting debris (from both Earth and the impacting body) accumulated to form the Moon. Scientists believe that the Moon was formed approximately 4.5 billion years ago. When the Moon formed, its outer layers melted under very high temperatures, forming the lunar crust, probably from a global "magma ocean."

## Moon Fast Facts



*This photograph of the Moon was taken by the Apollo 11 astronauts on their return flight to Earth.*

Average Distance from Earth	384,467 kilometers (238,897 miles)
Equatorial Radius	1737.4 kilometers (1079.6 miles)
Equatorial Circumference	10,916 kilometers (6,783 miles)
Volume	21,970,000,000 cubic kilometers By Comparison: 0.020 x Earth
Mass	73,483,000,000,000,000,000 kilograms By Comparison: 0.0123 x Earth
Density	Metric: 3.341 g/cm <sup>3</sup> By Comparison: 0.606 x Earth
Surface Area	37,932,330 km <sup>2</sup> (14,645,750 mi <sup>2</sup> ) By Comparison: 0.074 x Earth
Equatorial Surface Gravity	1,622 m/sec <sup>2</sup> , English: 5.322 ft/sec <sup>2</sup> By Comparison: 0.166 x Earth
Sidereal Rotation Period (Length of Day)	27.321661 Earth days (655.72 hours) Synchronous With Earth
Sidereal Orbit Period (Length of Year)	0.075 Earth years (27.321661 Earth days) Orbit Period = Rotation Period
Mean Orbit Velocity	3,682.8 kilometers per hour (2,288.4 miles per hour) By Comparison: 0.034 x Earth
Orbital Eccentricity	0.05490 — By Comparison: 3.285 x Earth
Equatorial Inclination to Orbit	6.68 degrees
Orbital Circumference	2,290,000 kilometers (1,423,000 miles)
Minimum/Maximum Surface Temperature	-233/123 degrees C (-387/253 degrees F)

For more information about Earth's Moon, go to: <http://sse.jpl.nasa.gov/planets/profile.cfm?Object=Moon>

National Aeronautics and Space Administration

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